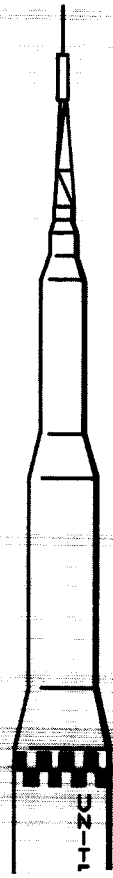
INTEGRAL SENSOR TELEMETRY

FINAL REPORT



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GENERAL ELECTRIC

INTEGRAL SENSOR TELEMETRY
FINAL REPORT

Contract NAS 8-11715

30 June 1965

Apollo Support Department
General Electric Company
Daytona Beach, Florida

ABSTRACT

This report describes effort on Phase B, Part I and reviews Phase A of Contract NAS 8-11715, Integral Sensor Telemetry.

The purpose of Phase A was to study the application of integral sensor transmitters to factory checkout. Included in this effort were:

a. Definition of the system requirements and the generation of an equipment specification for five sensor transmitters to be used in ATCOMED facility of the Quality and Reliability Assurance Laboratory at MSFC.
b. Evaluation of then available sensor transmitters to the specification.
c. Definition of system requirements for an ultimate integral sensor system for factory vehicle checkout.

As a result of the studies conducted Phase A, it was concluded that the presently available transmitters would meet the specifications for the five transmitters for the ATCOMED facility, and a set of requirements were defined for the ultimate system. Since some question of explicit requirements for the ultimate system still exist, particularly in the area of signal propagation, a follow-on program for an intermediate system, beyond Phase B of this contract, is recommended. This system is to be a multichannel system for use on board the S-IC vehicle. A recommended specification for this system is included in the Phase A report.

Phase B of the contract called for the fabrication and delivery of a five-channel miniature telemetry system based on the specification of Phase A. Included in this task were:

a. Fabrication of five sensor transmitters.
b. Preparation of the test procedure for testing the transmitters to the specification.
c. Preparation of operating and maintenance instructions.
d. Acceptance testing of the equipment.

The transmitters were tested and approved by the Contracting Officer's representative at the General Electric Daytona Beach Facilities during the week of 1 June 1965. The transmitters were shipped to MSFC on 18 June 1965.

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SECTION 1

PURPOSE

The purpose of this program was to investigate the feasibility of applying the integral sensor concept to factory stage checkout of a Saturn type vehicle. In its ultimate form, an integral sensor telemetry system would consist of a miniature transmitter, with a sensor that is integral with the transmitter, transmitting the sensed data by radio frequency propagation to a central receiving facility. A system of this type would eliminate the hard wire, its connector, and attendant problems between the sensor and the point where the data is utilized. The integral sensor system also offers the ultimate in instrumentation flexibility. With this system, sensors can be moved as required without the chore of rerouting cabling with its associated probability of damaging other vehicle equipment. Where no physical tie-in to the vehicle systems is required, such as zone temperature measurements, changing the data point is accomplished simply by moving the sensor/transmitter package to the desired location. A system of this type would greatly facilitate the factory checkout of large space vehicles, offering a reduction in checkout time and providing test data from the most desirable points of the vehicle systems.

SECTION 2

SCOPE

Under this contract, NAS 8-11715, Part I, the total program is divided into two major parts designated Phase A and Phase B. Phase A is the requirements study and Phase B is the application and evaluation phase.

Phase A is further subdivided into two parts. Part I is devoted to the study of the application of engineering model transmitters to subsystem module test in the ATCOMED facility of the Quality and Reliability Assurance laboratory at MSFC. The result of this study is a specification for five miniature telemetry transmitters to be delivered in Phase B of the contract.

Part II of Phase A is an application study to define the characteristics of an ultimate miniature telemetry system (transmitters and receivers), suitable as carry-on checkout telemetry equipment. This system would be used to replace the present hardwire system that is normally added to each vehicle during factory checkout. This study effort resulted in a definition of requirements for a system to perform this function.

In Phase B of the contract five sensor transmitters were fabricated, tested, and delivered to MSFC for further evaluation. It is expected that these units will prove the feasibility of the integral sensor concept and will provide valuable feedback on the practical application of the devices in vehicle checkout.

SECTION 3

PHASE A, PART 1

3.1 DISCUSSION

Phase A Part 1 was devoted to defining the requirements and the generation of a specification for the five miniature telemetry transmitters. These transmitters are to be used, with receivers loaned by the General Electric Company, to demonstrate the advantages of the integral sensor approach to factory checkout. The transmitters are to be used with the module carts of the ATCOMED facility. The transmitters will be mounted on the module carts, modulated by the data from conventional sensors on the module carts, and resultant data transmitted to a central receiver facility.

The best information available to date indicates that the sensors to be used on the module carts are as listed in Table 3-1.

Table 3-1
Available Sensors for Use on Module Carts

Module Cart	Sensor	Manufacturer	Part Number
Control System	Pressure	Edcliff	2-8-6 (0-3000 psi)
	Pressure	Edcliff	2-8-6 (0-750 psi)
Fuel System	Pressure Switch	Frebank	4188-1
LOX System	Pressure Switch	Frebank	4184-1
	Pressure Switch	Frebank	4184-2

No information on the sensors for the engine and guidance modules has been made available. The pressure transducers are potentiometer types with a nominal resistance of 2 kilohms. The pressure switch output will be a contact open or closed.

The receivers to be furnished to test the transmitters will be modified commercial receivers. The data output from these receivers will be in analog form, 0 to 5 volts.

The system will therefore consist of the transmitters mounted on the module carts which will be somewhere in the ATCOMED facility, transmitting pressure data to a central receiver location where the data is presented as an analog signal of 0-5 volts. This system will not be representative of an actual vehicle checkout telemetry system, but it will serve to demonstrate the flexibility and convenience of the integral sensor approach to checkout.

3.2 TRANSMITTER REQUIREMENTS

The basic requirements for the transmitters for this application are as follows:

a. The transmitters must be capable of operating in the working environment of the hangar area of building 4708 at MSFC.
b. The transmitters must be capable of sufficient accuracy to provide useful data from the module carts.
c. The transmitters must be compatible with either the sensors specified for the module carts or with a substitute transducer complying with the requirements of the Quality and Reliability Assurance Laboratory.
d. The transmitters must have a self-contained power supply with sufficient capacity to operate the transmitters for a reasonable length of time.
e. Physical characteristics, such as size, weight, and dimensions, are not particularly critical in this application but size should be held to a minimum. The size of the transmitter antenna should also be as small as possible, consistent with adequate performance.

In consultation with Quality and Reliability Assurance laboratory personnel, these general requirements were further definitized.

The working environment of the hangar area of building 4708 was defined as having an ambient temperature range of from 40°F to 140° F and a background RF noise level in the vicinity of the ATCOMED facility of 30 db above 1 microvolt/Mc as measured with an NF 105. It was also concluded that the shock and vibration conditions would be no greater than those experienced in normal laboratory handling.

To provide useful evaluation data, the system accuracy, from transmitter input to receiver output, the random error must be no more than 5 percent of full scale when measured under steady-state conditions. An accuracy of 3 percent of full scale was considered to be highly desirable.

The input to the transmitters from the module cart sensors was defined as being the standard telemetry modulation level (0 to +5 volts). The sensors and their output impedance characteristics have been discussed previously.

The primary power for the transmitters is to be supplied by a self-contained battery. Since the useful life of the battery and its physical size are directly interrelated, a compromise must be reached. It was felt that changing batteries once a week would not be unreasonable; therefore, a useful battery life of 100 hours was agreed on. This would allow twelve, 8-hour shifts of continuous operation. When the transmitters are not used continuously, the time between battery changes would of course be extended.

These requirements have been incorporated into the specification for the transmitters to be delivered in Phase B of the contract.

3.3 TRANSMITTER SPECIFICATION

The following specification defines the characteristics of the five miniature telemetry transmitters to be delivered in Phase B of this contract, NAS 8-11715, Part I.

3.3.1 OPERATIONAL SPECIFICATIONS

3.3.1.1 Frequency of Operation

The transmitters for this application will operate on the frequencies listed in Table 3-2.

Table 3-2
Transmitter Frequencies

Channel	Frequency in Mc
1	27.650
2	27.700
3	27.750
4	27.800
5	27.850

These frequencies were chosen since they are within the operating range of presently available equipment and are also within a frequency band assigned for Government use.

3.3.1.2 Accuracy

The over-all system accuracy from transmitter input to receiver output shall be 5 percent of full scale or better. Three percent of full scale is to be a system goal. These error figures are for a steady-state measurement exclusive of any timing or phase errors. To maintain this accuracy, end-point calibration will be required no more often than every 24 hours.

3.3.1.3 Transmission Range

The transmitter-receiver system shall be capable of useful operation over a range of up to 300 feet between transmitting and receiving antennas. This range of operation is for a 12-inch monopole transmitting antenna, an ambient RF noise level of 30 db above 1 microvolt/Mc, and a free-space transmission medium. The receiver is assumed to be external noise limited.

3.3.1.4 Data Bandwidth

The system will be capable of transmitting data frequencies of from 0 to 80 cps at the specified accuracy.

3.3.1.5 Modulation Input

The transmitters to be supplied will accept a modulation input of from 0 to +5 volts with a transmitter input impedance greater than 40,000 ohms.

3.3.1.6 Calibration

Calibration will be accomplished by insertion of a calibration probe with "zero and full scale" switch.

3.3.1.7 Mode of Operation

The transmitter will be equipped with a manual on-off switch.

3.3.1.8 Power Supply

The transmitter will be supplied with self-contained batteries with sufficient capacity to operate the transmitter for a minimum period of 100 hours.

3.3.2 ENVIRONMENTAL SPECIFICATIONS

3.3.2.1 Temperature

The transmitter will be capable of operation at the specified accuracy over the temperature limits of 40°F to 140°F. Receiver will operate over a temperature range of 50°F to 130°F.

3.3.2.2 Shock and Vibration

The transmitters will be constructed to conform to good commercial practice and will be sufficiently rugged for normal laboratory handling.

3.3.3 MECHANICAL SPECIFICATIONS

3.3.3.1 Size

The transmitter, exclusive of antenna, will be no larger than 4 inches by 3 inches by 1 inch.

3.3.3.2 Weight

The transmitter package will not exceed 10 ounces in weight.

3.3.3.3 Antenna

The transmitting antenna will be a monopole antenna not exceeding 12 inches in physical length.

3.3.3.4 Mounting

The transmitter package will incorporate suitable mounting hardware to effect convenient and secure mounting of the transmitters to the module carts.

3.4 EQUIPMENT EVALUATION

A presently available sensor transmitter was tested to the specification of the five channel system to be delivered in Phase B of this contract. The results of these tests are described in following paragraphs.

3.4.1 ACCURACY

Total system bias errors over a 24-hour period and a temperature range of 40°F to 140°F did not exceed 2 percent. This error is from the following sources. (See Table 3-3.)

Table 3-3
Error Sources

Source	Error (percent)
Transmitter-Voltage Control	1
Oscillator Frequency Shift	
40°F to 140°F	
Receiver Data Recovery Unit	0.21
40°F to 140°F	
Transmitter-Voltage Control Oscillator	0.12
Frequency Shift over 24 hours (measured at room temperature)	
Receiver Conversion Error	1.5

An additional error of up to 2 percent may be incountered as a result of loading of the sensor by the transmitter, but this can be reduced by proper choice of sensor impedance.

The random error component of system accuracy is primarily a function of the signal-to-noise ratio at the receiver, with the noise level being a function of the environment. The receiver for this system was simulated using the GEESE analog computer facility to evaluate the effects of signal-to-noise ratios*. The results of this simulation indicate the following accuracy can be obtained for the indicated signal-to-noise ratios. (See Table 3-4.)

Table 3-4
Receiver Signal-to-Noise Ratio as Simulated on GEESE Computer

S/N in db	Error (percent)
+10	4.02
+16	1.91
+19	1.23
+22	0.90

*See Integral Sensor Telemetry Phase A Report, dated 12 February 1965.

The transmitter tested produced a signal level of 43.2 db above 1 microvolt/meter at a range of 300 feet. For an assumed background noise level of 30 db above 1 microvolt/megacycle or 8 db above 1 microvolt/meter in a 10 kc bandwidth this results in a signal-to-noise ratio of 35.2 db. The random error component in the 5-channel system should therefore be much less than 1 percent. The total system error then should fall within the 3 percent to 5 percent specified.

3.4.2 TRANSMISSION RANGE

As previously discussed, the transmitter is easily capable of useful operations at a distance of 300 feet under the assumed conditions.

3.4.3 DATA BANDWIDTH

The accuracy discussed above is for a data bandwidth of 100 cps. Operation with data at 0-80 cps is encompassed.

3.4.4 MODULATION INPUT

The transmitter was designed to accept 0 to +5 volt modulation input and an input impendance in excess of 40,000 ohms.

3.4.5 POWER SUPPLY

The tested transmitter is capable of about 80 hours of continuous operation with the battery size consistent with the package size specified. Improvements in transmitter efficiency is expected to increase battery life.

3.4.6 ENVIRONMENTAL SPECIFICATIONS

As indicated under the accuracy discussion on page 3-6, the system will perform satisfactorily over the specified temperature range.

3.4.7 MECHANICAL SPECIFICATIONS

Packaging is within the specified size and weight limits.

The transmitter is packaged in a 1/16-inch thick aluminum case and exceeds normal good commercial practice.

SECTION 4

INTEGRAL SENSOR TRANSMITTER TEST PROCEDURE

4.1 GENERAL

To insure that the transmitters meet the specifications described in the preceding section, the following test procedure was prepared and approved by the Contracting Officer. The test procedure calls for the complete testing of all transmitters. This requirement was modified to provide selected tests on each of the transmitters during the acceptance test by the Contracting Officer's representative who witnessed the test. The remainder of the test will be performed following the actual acceptance test.

The Transmission Range Test was deferred until the transmitters were received at MSFC. This was done at MSFC's request since approval to use the transmitter frequencies in Daytona Beach had not been received at the time of the test.

4.2 DISCUSSION OF TESTS

The test described in this document will constitute the acceptance test for the five sensor transmitters to be supplied in Part I Phase B of Contract NAS8-11715. The complete test procedure will be performed on all five transmitters.

In all tests the transmitter and associated receiver will be set up and adjusted for proper operation as specified in the operating instructions furnished with the transmitter.

Data sheets will be used to record the test data. The data sheets will contain the test setups listing the instrumentation used and the specification limits for the test. The data sheets will be delivered to MSFC with the transmitters.

4.3 TEST SETUP

For the following test the transmitter and receiver will be operated over a convenient distance in the laboratory. The transmitter will be supplied with a simulated modulation signal from a 2000-ohm potentiometer and a 5.0-volt regulated power supply. Digital voltmeters will be used to measure the input to the transmitter and the analog output from the data recovery unit of the receiver. (See Figure 4-1.) The system will then be calibrated according to the operating instructions.

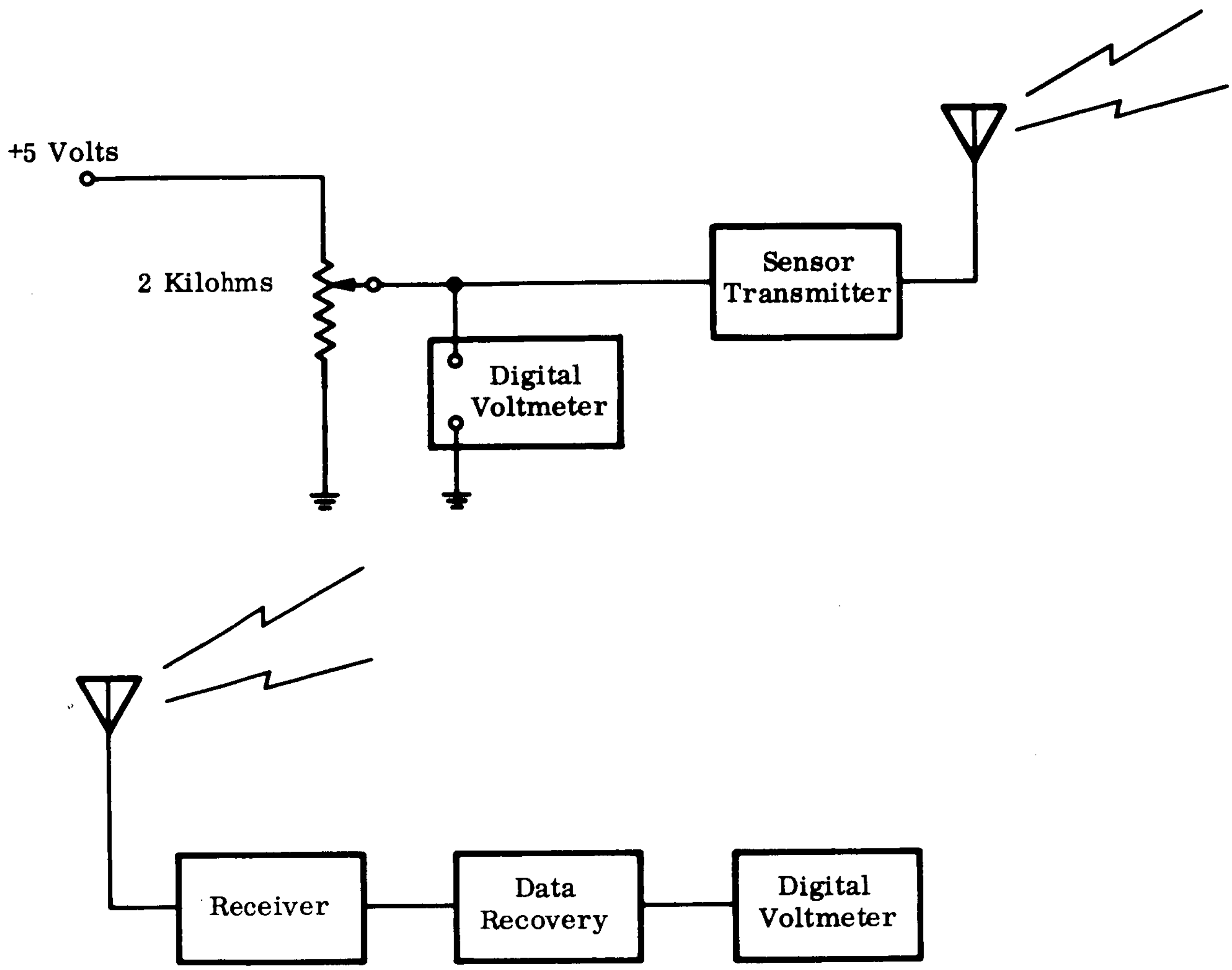


Figure 4-1. Integral Sensor Transmitter Test Setup

4.3.1 BASIC ACCURACY TEST

This test will be conducted using dc modulation and will show the basic accuracy of the system under high signal-to-noise conditions.

In this test the transmitter input potentiometer will be adjusted to give modulation voltages of 0, 1, 2, 3, 4, and 5 volts. At each voltage level, the receiver output level will be read and recorded. The difference in input and output meter readings referenced to 5 volts full scale is the system transmission error and is a portion of the over-all system error.

4.3.2 TRANSMISSION RANGE

The purpose of this test is to verify that the transmitter will produce an acceptable signal level at the maximum range.

The transmitter will be set up at a distance of 300 feet from the Empire Devices NF-105 Noise and Field Intensity Meter under conditions approximating free-space propagation. With the transmitter unmodulated, the field intensity will be measured in db above 1 microvolt/meter. The ratio of this reading to the assumed noise level of 30 db above 1 microvolt connected to the receiver bandwidth of 10 kc (8 db above 1 microvolt/meter) gives the signal-to-noise ratio available at the receiver. The presence of noise in the system produces a random error in the output data. The effects of a given signal-to-noise ratio were evaluated by simulation of the receiver on the GEESE analog computer. The following mean squared error components were found for the indicated S/N ratios (Table 4-1).

Table 4-1

Error Components for the Indicated S/N Ratios

S/N (db)	Error (percent)
+10	4.02
+16	1.91
+19	1.23
+22	0.90

Using Table 4-1, the random error component of the system accuracy can be determined.

4.3.3 DATA BANDWIDTH TEST

This test is to verify the capability of the system to handle data frequencies up to 80 cps.

For this test, the 5 volt dc supply will be replaced by a signal generator to supply 5.0 volt peak-to-peak ac modulation to the transmitter. (See Figure 4-2.)

The input level to the transmitter and the output level from the receiver data recovery unit will be measured using Fluke meters, Model No. 803B. In this test input levels of 0.5, 1.0, and 1.5 volt rms at the following frequencies will be supplied to the transmitter modulation input.

Frequencies (cps)
5
10
20
30
40
50
60
70
80

The receiver output level will be read and recorded at each input level and frequency. The difference in input and output readings referred to 1.767 volts rms (full scale of 5 volts peak to peak) is the error at the particular frequency.

4.3.4 MODULATION INPUT

Paragraphs 4.3.1 and 4.3.2 demonstrate the compatibility of the transmitter to accept modulation of 0 to +5 volts. Examination of the transmitter schematic clearly indicates the input impedance is in excess of 40,000 ohms and no test is considered necessary (42,000-ohm resistor in series with the input).

4.3.5 CALIBRATION

Initial setup and calibration demonstrates calibration using the calibration probe.

4.3.6 MODE OF OPERATION

Examination of the transmitter package will show the presence of the manual on-off switch which is so labeled.

4.3.7 POWER SUPPLY TEST

This test is to determine the useful life of the transmitter batteries. Three separate voltages are used in the transmitter with each being supplied by separate batteries.

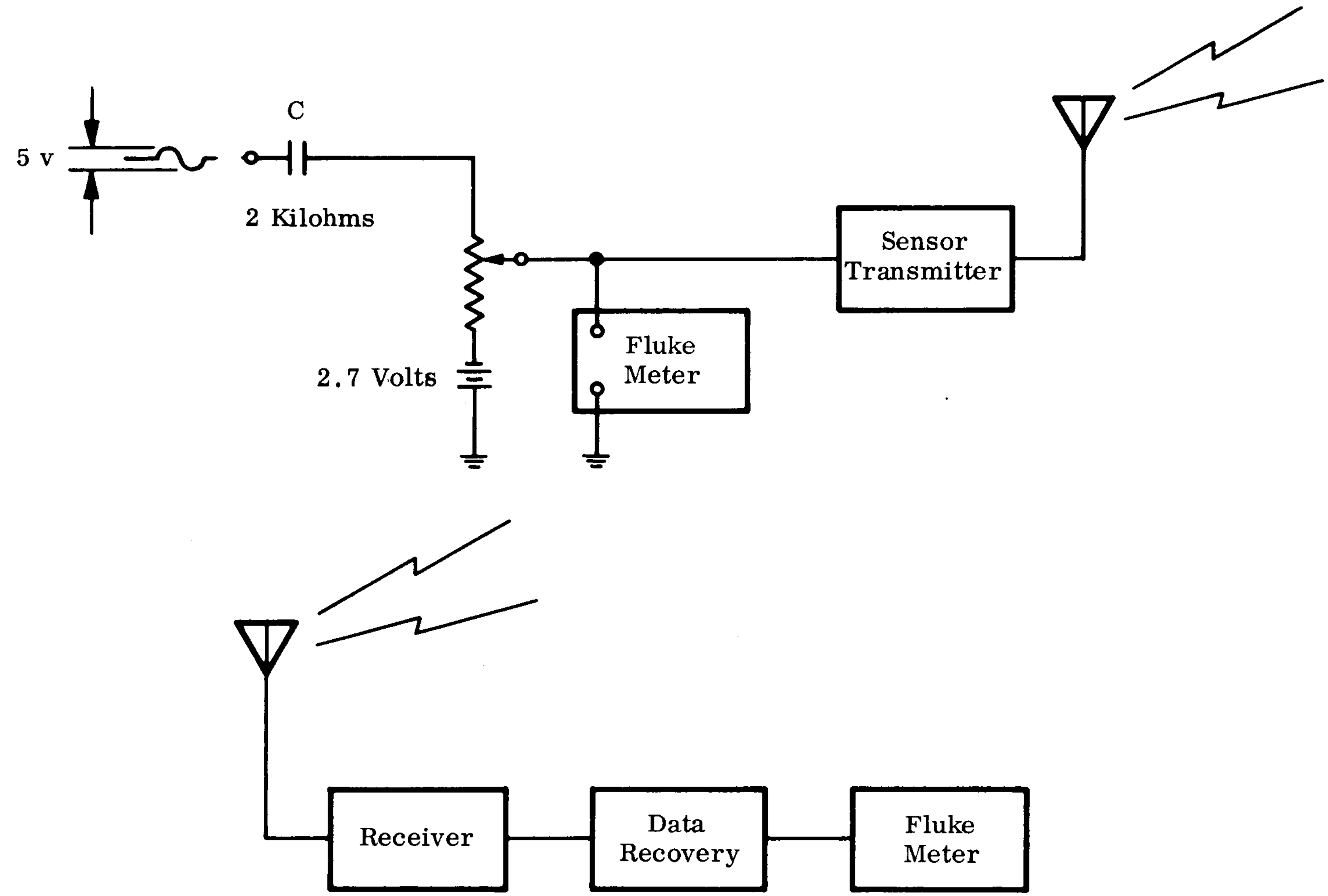


Figure 4-2. Basic Bandwidth Test Setup

The batteries used in this transmitter are mercury cells. The characteristics of these cells is such that the capacity in milliampere-hours is essentially constant with current drain and duty cycle. The useful life of the cell can therefore be reasonably estimated from the rated capacity of the batteries and the cutoff voltage determined by the equipment. The battery life will be checked by measuring the initial current, using new batteries at each of the three voltages, and computing battery life from the manufacturer's published data.

A change in battery voltage occurring as a result of battery ageing can contribute to the total system error. To evaluate this source of error a transmitter will be operated with its associated receiver for a period of 24 hours, the time between calibrations. For this test the modulation input will be grounded, and the change in zero reading at the receiver output at the end of the 24-hour period referred to full scale is the error due to the voltage change in the batteries. This test will be conducted at room temperature.

4.3.8 TEMPERATURE TEST

This test is designed to evaluate the drift error in the system as a result of temperature effects on the transmitter. For this test the transmitter will be placed in an environmental chamber with the antenna extending outside the chamber. The receiver will be set up a convenient distance from the transmitter and the output voltage monitored with a digital voltmeter. In this test the transmitter modulation input will be grounded. The transmitter is to be tested over a temperature range of 40°F to 140°F in 20°F steps. The transmitter is to remain at each temperature level for a period of one hour. At the end of this period the receiver output voltage will be read and recorded. The change in output voltage will be the drift error resulting from temperature changes.

4.3.9. SHOCK AND VIBRATION

The transmitters are being assembled to Apollo Support Department commercial standards as covered by ASD document, <u>Standard Shop Run Tolerances and Shop Practice</u>, and ASD-STD-501/1, <u>Soldering Workmanship Practices and Reliable Soldering Standard for Electronic Equipment</u>. The transmitters are also being inspected during assembly by Quality Assurance personnel.

4.4 INTERPRETATION OF ERROR MEASUREMENTS

The total system error for this system is composed of the random component which results from system noise and is a function of S/N ratio as described in paragraph 4.3.2. The second error component is the systematic or drift error associated with the equipment such as temperature drift, battery voltage drop, bias errors, etc. The components of this error were measured in paragraphs 4.3.1, 4.3.3, 4.3.7, and 4.3.8. To obtain the total drift error, the RMS value of the above components will be used. The total system error will be taken as the RMS vector sum of the random error and the drift error. This total system error is to be less than 5 per cent of full scale referred to the input.

4.5 TEST DATA

4.5.1 DISCUSSION

The following data sheets document the results of the test on the five transmitters.

In the power supply test, previous tests indicate that V_1 is the most critical battery in determining the satisfactory operating life of the power supply; therefore, only this voltage and current were checked. The computed service life is derived from the manufacturer's battery rating of 500 milliampere hours for the MALLORY type TR-162R battery. Due to the time required and the insignificant error noted on the one transmitter checked, the 24-hour test was not performed on the transmitters. The transmitter checked during the acceptance test had less than 0.2 per cent drift in 24 hours.

Modified temperature tests (3 points) were authorized by the Contracting Officer's representative. During the acceptance test one transmitter was run through the complete test and the extremes and the peak error point were chosen as the test points for the other transmitters.

The total systematic errors for the transmitters are as follows:

Transmitter No.	Error (percent)
1	1.99
2	2.50
3	1.73
4	3.73
5	1.35

These numbers were arrived at by taking the RMS values of the worst case in each individual test. The allowable systematic error is 4.5 percent. The random error component of the total error will be determined from the Transmitter Range Test which will give the operating S/N ratio.

SENSOR TRANSMITTER DATA SHEET

1.0 Basic Accuracy Test

1.1 Test Equipment

Input Voltmeter	Model: Fluke Model 803B
	Serial No.: 1496
Output Voltmeter	Model: Fluke Model 803B
	Serial No.: 1498

1.2 Test Setup

The test setup shall be in accordance with Figure 4-1 of this publication.

1.3 Test Data

Input (volts)	Output (volts)	Error (volts)	Error (percent)
0.0	0.003	0.003	0.06
1.0	1.019	0.019	0.38
2.0	2.025	0.025	0.50
3.0	3.029	0.029	0.58
4.0	4.033	0.033	0.66
5.0	4.984	0.016	0.32

Max. Error in Volts 0.033

Max. Error in Percent 0.66

SENSOR TRANSMITTER DATA SHEET

2.0 Data Bandwidth Test

2.1 Test Equipment

Input Voltmeter	Model: Fluke Model 803B Serial No.: 1496
Output Voltmeter	Model: Fluke Model 803B Serial No.: 1498

2.2 Test Setup

The test setup shall be in accordance with Figure 4-2 and paragraph 4.3.3 of this publication.

2.3 Test Data

Frequency (cps)	Output (volts)	Error (volts)	Error (percent)
	Input Level	Input Level	Input Level
	1.5v	1.5v	1.5v
5	1.530	0.030	1.70
10	1.510	0.010	0.56
20	1.495	0.005	0.28
30	1.485	0.001	0.06
40	1.467	0.012	0.68
50	1.450	0.014	0.79
60	1.431	0.017	0.96
70	1.407	0.021	1.19
80	1.381	0.025	1.42

Max. Error in Volts 0.030

Max. Error in Percent 1.70

SENSOR TRANSMITTER DATA SHEET

3.0 Power Supply Test

3.1 Test Equipment

DC Voltmeter	Model: Fluke 803B
	Serial No.: 1498
DC Milliammeter	Model: Weston 931
	Serial No.: 55921

3.2 Test Setup

The test setup shall be in accordance with paragraph 4.3.7 of this publication.

3.3 Test Data

Battery Life Test

Initial Drain in MA @	Computed Service Life
V_1 $\cancel{V_2}$ $\cancel{V_3}$	V_1 $\cancel{V_2}$ $\cancel{V_3}$
V_1 = 7.887v @5.1 ma. ___ ___ ___	98 hrs ___ ___ ___

24-Hour Error Test

Start		Stop		Error (volts)	Error (percent)
Date	_____	Date	_____		
Time	_____	Time	_____		
Rec Out	_____	Rec Out	_____	_____	_____

SENSOR TRANSMITTER DATA SHEET

4.0 Temperature Test

4.1 Test Equipment

Environmental Chamber	Model: Statham SD-C
	Serial No.:
Digital Voltmeter	Model: Cubic V-70
	Serial No.: 387

4.2 Test Setup

The test setup shall be in accordance with paragraph 4.3.8 of this publication.

Two transmitters will be checked simultaneously.

The transmitters will be calibrated at room temperature.

4.3 Test Data

Temp (°F)	Trans Input (volts)	Rec Output (volts)
40	2.500	2.481
100	2.500	2.540
140	2.500	2.580

Error in Volts 0.040

Error in percent of full scale 0.8

SENSOR TRANSMITTER DATA SHEET

5.0 Transmission Range

5.1 Test Equipment

Field Intensity Meter	Model:
	Serial No.:
Tuning Unit	Model:
	Serial No.:
Antenna	Model:
	Serial No.:

5.2 Test Setup

The test setup shall be in accordance with paragraph 4.3.2 of this publication. The loop antenna used in this test is to be oriented for maximum signal level.

5.3 Test Data

Range	Signal Level (db>1uv/meter)	Assumed Noise Level (8db)	S/N Ratio	Error* in percent

*See paragraph 4.3.2 of this publication. Maximum allowable error is 2 percent or +16 db S/N ratio.

SENSOR TRANSMITTER DATA SHEET

6.0 Interpretation of Error Measurements

As indicated by the test procedure paragraph 4.4, the total system error is composed of the systematic and random components. The random component of the error is to be limited to 2 percent. The systematic error is to be limited to 4.5 percent. The total system error shall not exceed 5 percent and comprises the vector sum of the random and systematic error. The systematic error is the RMS value of the error measured in paragraphs 1.0 through 4.0.

Random Error (E_R) = ________

Systematic Error (E_S) = 1.99%

System Error ($E = \sqrt{E_R^2 + E_s^2}$ = ________

SENSOR TRANSMITTER DATA SHEET

Transmitter VCO period versus Modulation Voltage

Volts	Period (usec)	ΔT (usec)
0.0	387.0	
1.0	406.7	19.7
2.0	426.5	20.2
3.0	446.5	20.0
4.0	466.4	19.9
5.0	486.3	19.9

SENSOR TRANSMITTER DATA SHEET

1.0 Basic Accuracy Test

1.1 Test Equipment

Input Voltmeter	Model: Fluke Model 803B
	Serial No.: 1498
Output Voltmeter	Model: Fluke Model 803B
	Serial No.: 1496

1.2 Test Setup

The test setup shall be in accordance with Figure 4-1 of this publication.

1.3 Test Data

Input (volts)	Output (volts)	Error (volts)	Error (percent)
0.0	0.003	0.003	0.06
1.0	0.953	0.047	0.94
2.0	1.940	0.060	1.20
3.0	2.948	0.052	1.04
4.0	3.945	0.055	1.10
5.0	4.933	0.067	1.34

Max. Error in Volts 0.067

Max. Error in Percent 1.34

SENSOR TRANSMITTER DATA SHEET

2.0 Data Bandwidth Test

2.1 Test Equipment

Input Voltmeter	Model: Fluke Model 803B
	Serial No.: 1498
Output Voltmeter	Model: Fluke 803B
	Serial No.: 1496

2.2 Test Setup

The test setup shall be in accordance with Figure 4-2 and paragraph 4.3.3 of this publication.

2.3 Test Data

Frequency (cps)	Output (volts)	Error (volts)	Error (percent)
	Input Level	Input Level	Input Level
	1.5v	1.5v	1.5v
5	1.480	0.020	1.13
10	1.491	0.009	0.51
20	1.493	0.007	0.40
30	1.471	0.022	1.24
40	1.460	0.018	1.02
50	1.440	0.024	1.36
60	1.430	0.017	0.96
70	1.400	0.029	1.64
80	1.370	0.037	2.09

Max. Error in Volts 0.037

Max. Error in Percent 2.09

SENSOR TRANSMITTER DATA SHEET

3.0 Power Supply Test

3.1 Test Equipment

DC Voltmeter	Model: Fluke 803B
	Serial No.: 1498
DC Milliammeter	Model: Weston 931
	Serial No.: 55921

3.2 Test Setup

The test setup shall be in accordance with paragraph 4.3.7 of this publication.

3.3 Test Data

Battery Life Test

Initial Drain in MA @	Computed Service Life
V_1 $\cancel{V_2}$ $\cancel{V_3}$	V_1 $\cancel{V_2}$ $\cancel{V_3}$
V_1 = 7.91v @5.2 ma ___ ___ ___	96 hrs ___ ___ ___

24-Hour Error Test

Start		Stop		Error (volts)	Error (percent)
Date	______	Date	______		
Time	______	Time	______		
Rec Out	______	Rec Out	______	______	______

SENSOR TRANSMITTER DATA SHEET

4.0 Temperature Test

4.1 Test Equipment

Environmental Chamber	Model: Statham SD-6
	Serial No.:
Digital Voltmeter	Model: Cubic V-70
	Serial No.: 387

4.2 Test Setup

The test setup shall be in accordance with paragraph 4.3.8 of this publication.

Two transmitters will be checked simultaneously.

The transmitters will be calibrated at room temperature.

4.3 Test Data

Temp (°F)	Rec Input (volts)	Rec Output (volts)
40	2.500	2.486
100	2.500	2.498
140	2.500	2.498

Error in Volts 0.014

Error in Percent of full scale 0.28

SENSOR TRANSMITTER DATA SHEET

5.0 Transmission Range

5.1 Test Equipment

Field Intensity Meter	Model:
	Serial No.:
Tuning Unit	Model:
	Serial No.:
Antenna	Model:
	Serial No.:

5.2 Test Setup

The test setup shall be in accordance with paragraph 4.3.2 of this publication. The loop antenna used in this test is to be oriented for maximum signal level.

5.3 Test Data

Range	Signal Level (db>luv/meter)	Assumed Noise Level (8db)	S/N Ratio	Error* (percent)

*Error is obtained from the table in paragraph 4.3.2. Maximum allowable error is 2 percent or +16 db S/N ratio.

SENSOR TRANSMITTER DATA SHEET

6.0 Interpretation of Error Measurements

As indicated by the test data procedure, paragraph 4.4, the total system error is composed of the systematic and random components. The random component of the error is to be limited to 2 percent. The systematic error is to be limited to 4.5 percent. The total system error shall not exceed 5 percent and is composed of the vector sum of the random and systematic error. The systematic error is the RMS value of the error measured in paragraphs 1.0 through 4.0.

Random Error (E_R) = ________

Systematic Error (E_s) = 2.5%

System Error (E = $\sqrt{E_R^2 + E_s^2}$ = ________

SENSOR TRANSMITTER DATA SHEET

Transmitter VCO period versus Modulation Voltage

Volts	Period (usec)	ΔT (usec)
0.0	375.8	
1.0	395.6	19.8
2.0	415.5	19.9
3.0	435.5	20.0
4.0	455.2	19.7
5.0	475.2	20.0

SENSOR TRANSMITTER DATA SHEET

1.0 Basic Accuracy Test

1.1 Test Equipment

Input Voltmeter — Model: Fluke Model 803B
Serial No.: 1498

Output Voltmeter — Model: Fluke Model 803B
Serial No.: 1496

1.2 Test Setup

The test setup shall be in accordance with Figure 4-1 and paragraph 4.3.1 of this publication.

1.3 Test Data

Input (volts)	Output (volts)	Error (volts)	Error (percent)
0.0	0.017	0.017	0.34
1.0	1.011	0.011	0.22
2.0	2.009	0.009	0.18
3.0	2.994	0.006	0.12
4.0	3.988	0.012	0.24
5.0	4.975	0.025	0.50

Max. Error in Volts 0.025

Max. Error in Percent 0.5

SENSOR TRANSMITTER DATA SHEET

2.0 Data Bandwidth Test

2.1 Test Equipment

Input Voltmeter	Model: Fluke Model 803B Serial No.: 1498
Output Voltmeter	Model: Fluke Model 803B Serial No.: 1496

2.2 Test Setup

The test setup shall be in accordance with Figure 4-2 and paragraph 4.3.3 of this publication.

2.3 Test Data

Frequency (cps)	Output (volts)	Error (volts)	Error (percent)
	Input Level	Input Level	Input Level
	1.5v	1.5v	1.5v
5	1.482	0.018	1.02
10	1.497	0.003	0.17
20	1.493	0.007	0.40
30	1.485	0.001	0.06
40	1.471	0.007	0.40
50	1.456	0.008	0.45
60	1.433	0.014	0.79
70	1.408	0.020	1.13
80	1.380	0.026	1.47

Max. Error in Volts <u>0.026</u>

Max. Error in Percent <u>1.47</u>

SENSOR TRANSMITTER DATA SHEET

3.0 Power Supply Test

3.1 Test Equipment

DC Voltmeter	Model: Fluke 803B
	Serial No.: 1498
DC Milliammeter	Model: Weston 931
	Serial No.: 55921

3.2 Test Setup

The test setup shall be in accordance with paragraph 4.3.7 of this publication.

3.3 Test Data

Battery Life Test

Initial Drain in MA @	Computed Service Life
V_1 $\cancel{V_2}$ $\cancel{V_3}$	V_1 $\cancel{V_2}$ $\cancel{V_3}$
V_1 = 7.947 @ 4.5 ma ____ ____ ____	111 hrs ____ ____ ____

24-Hour Error Test

Start		Stop		Error (volt)	Error (percent)
Date	______	Date	______		
Time	______	Time	______		
Rec Out	______	Rec Out	______	______	______

SENSOR TRANSMITTER DATA SHEET

4.0 Temperature Test

4.1 Test Equipment

Environmental Chamber	Model: Statham SD-6
	Serial No.:
Digital Voltmeter	Model: Cubic V-70
	Serial No.: 387

4.2 Test Setup

The test setup shall be in accordance with paragraph 4.3.8 of this publication.

Two transmitters will be checked simultaneously.

The transmitters will be calibrated at room temperature.

4.3 Test Data

Temp (°F)	Rec Input (volts)	Rec Output (volts)
40	2.500	2.462
100	2.500	2.521
140	2.500	2.520

Error in Volts 0.038

Error in Percent of full scale 0.76

SENSOR TRANSMITTER DATA SHEET

5.0 Transmission Range

5.1 Test Equipment

Field Intensity Meter	Model:
	Serial No.:
Tuning Unit	Model:
	Serial No.:
Antenna	Model
	Serial No.:

5.2 Test Setup

The test setup shall be in accordance with paragraph 4.3.2 of this publication. The loop antenna used in this test is to be oriented for maximum signal level.

5.3 Test Data

Range	Signal Level (db > luv/meter)	Assumed Noise Level (8db)	S/N Ratio	Error* (percent)

*Error is obtained from the table in paragraph 4.3.2 of the test procedure. Maximum allowable error is 2 percent or + 16 db S/N ratio.

SENSOR TRANSMITTER DATA SHEET

6.0 Interpretation of Error Measurements

As indicated in paragraph 4.4 of the test procedure, the total system error is composed of the systematic and random components. The random component of the error is to be limited to 2 percent. The systematic error is to be limited to 4.5 percent. The total system error shall not exceed 5 percent and is composed of the vector sum of the random and systematic error. The systematic error is the RMS value of the error measured in paragraphs 1.0 through 4.0.

Random Error (E_R) = ______

Systematic Error (E_s) = 1.73

System Error ($E = \sqrt{E_R^2 + E_s^2}$ = ______

SENSOR TRANSMITTER DATA SHEET

Transmitter VCO period versus Modulation Voltage

Volts	Period (usec)	ΔT (usec)
0.0	374.0	
1.0	393.9	19.9
2.0	414.0	20.1
3.0	434.0	20.0
4.0	453.9	19.9
5.0	473.9	20.0

SENSOR TRANSMITTER DATA SHEET

1.0 Basic Accuracy Test

1.1 Test Equipment

Input Voltmeter	Model: Fluke Model 803B
	Serial No.: 1498
Output Voltmeter	Model: Fluke Model 803B
	Serial No.: 1496

1.2 Test Setup

The test setup shall be in accordance with Figure 4-1 and paragraph 4.3.1 of this publication.

1.3 Test Data

Input (volts)	Output (volts)	Error (volts)	Error (percent)
0.0	0.000	0.000	0.00
1.0	0.937	0.063	1.20
2.0	1.956	0.044	0.88
3.0	2.980	0.020	0.40
4.0	3.994	0.006	0.12
5.0	5.000	0.000	0.000

Max. Error in Volts 0.063
Max. Error in Percent 1.2

SENSOR TRANSMITTER DATA SHEET

2.0 Data Bandwidth Test

2.1 Test Equipment

Input Voltmeter	Model: Fluke 803B
	Serial No.: 1498
Output Voltmeter	Model: Fluke 803B
	Serial No.: 1496

2.2 Test Setup

The test setup shall be in accordance with Figure 4-2 and paragraph 4.3.3 of this publication.

2.3 Test Data

Frequency (cps)	Output Volts	Error (volts)	Error (percent)
	Input Level	Input Level	Input Level
	1.5v	1.5v	1.5v
5	1.356	0.006	0.34
10	1.449	0.051	2.83
20	1.480	0.020	1.13
30	1.481	0.005	0.28
40	1.471	0.007	0.40
50	1.459	0.005	0.28
60	1.439	0.008	0.45
70	1.419	0.009	0.51
80	1.390	0.016	0.91

Max. Error in Volts 0.051

Max. Error in Percent 2.83

SENSOR TRANSMITTER DATA SHEET

3.0 Power Supply Test

3.1 Test Equipment

DC Voltmeter	Model: Fluke 803B
	Serial No.: 1498
DC Milliammeter	Model: Weston 931
	Serial No.: 55921

3.2 Test Setup

The test setup shall be in accordance with paragraph 4.3.7 of this publication.

3.3 Test Data

Battery Life Test

Initial Drain in MA @	Computed Service Life
V_1 ~~V_2~~ ~~V_3~~	V_1 ~~V_2~~ ~~V_3~~
V_1 = 7.905 @ 5.7 ma ___ ___ ___	88 hrs ___ ___ ___

24-Hour Error Test

Start		Stop		Error (volt)	Error (percent)
Date	______	Date	______		
Time	______	Time	______		
Rec. Out	______	Rec. Out	______	______	______

SENSOR TRANSMITTER DATA SHEET

4.0 Temperature Test

4.1 Test Equipment

Environmental Chamber	Model: Statham SD-6
	Serial No.:
Digital Voltmeter	Model: Cubic V-70
	Serial No.: 387

4.2 Test Setup

The test setup shall be in accordance with paragraph 4.3.8 of this publication.

Two transmitters will be checked simultaneously.

The transmitters will be calibrated at room temperature.

4.3 Test Data

Temp (°F)	Rec Input (volts)	Rec Output (volts)
40	2.500	2.394
100	2.500	2.460
140	2.500	2.460

Error in Volts 0.106

Error in Percent of full scale 2.12

SENSOR TRANSMITTER DATA SHEET

5.0 Transmission Range

5.1 Test Equipment

Field Intensity Meter	Model:
	Serial No.:
Tuning Unit	Model:
	Serial No.:
Antenna	Model:
	Serial No.:

5.2 Test Setup

The test setup shall be in accordance with paragraph 4.3.2 of this publication. The loop antenna used in this test is to be oriented for maximum signal level.

5.3 Test Data

Range	Signal Level (db >luv/meter)	Assumed Noise Level (8 db)	S/N Ratio	Error* (percent)
______	______________	___________	_____	________

*Error is obtained from paragraph 4.3.2 in the test procedure. Maximum allowable error is 2 percent or +16 db S/N ratio.

SENSOR TRANSMITTER DATA SHEET

6.0 Interpretation of Error Measurements

As indicated in paragraph 4.4, the total system error is composed of the systematic and random components. The random component of the error is to be limited to 2 percent. The systematic error is to be limited to 4.5 percent. The total system error shall not exceed 5 percent and is composed of the vector sum of the random and systematic error. The systematic error is the RMS value of the error measured in paragraphs 1.0 through 4.0.

Random Error (E_R) = ______

Systematic Error (E_s) = 3.73%

System Error ($E = \sqrt{E_R^2 + E_s^2}$ = ______

SENSOR TRANSMITTER DATA SHEET

Transmitter VCO period versus Modulation Voltage

Volts	Period (usec)	ΔT (usec)
0.0	388.7	
1.0	407.2	18.5
2.0	427.3	20.1
3.0	447.3	20.0
4.0	467.4	20.1
5.0	487.5	20.1

SENSOR TRANSMITTER DATA SHEET

1.0 Basic Accuracy Test

1.1 Test Equipment

Input Voltmeter	Model: Fluke Model 803B
	Serial No.: 1498
Output Voltmeter	Model: Fluke Model 803B
	Serial No.: 1496

1.2 Test Setup

The test setup shall be in accordance with Figure 4-1 and paragraph 4.3.1 of this publication.

1.3 Test Data

Input (volts)	Output (volts)	Error (volts)	Error (percent)
0.0	0.0008	0.001	0.02
1.0	0.981	0.019	0.38
2.0	1.990	0.010	0.20
3.0	2.980	0.020	0.40
4.0	3.980	0.020	0.40
5.0	4.974	0.026	0.52

Max. Error in Volts 0.026

Max. Error in Percent 0.52

SENSOR TRANSMITTER DATA SHEET

2.0 Data Bandwidth Test

2.1 Test Equipment

Input Voltmeter	Model: Fluke Model 803B
	Serial No.: 1498
Output Voltmeter	Model: Fluke Model 803B
	Serial No.: 1496

2.2 Test Setup

The test setup shall be in accordance with Figure 4-2 and paragraph 4.3.3 of this publication.

2.3 Test Data

Frequency (cps)	Output (volts)	Error (volts)	Error (percent)
	Input Level	Input Level	Input Level
	1.5v	1.5v	1.5v
5	1.480	0.020	1.13
10	1.490	0.010	0.58
20	1.490	0.004	0.23
30	1.480	0.005	0.28
40	1.469	0.010	0.58
50	1.456	0.008	0.45
60	1.438	0.009	0.51
70	1.421	0.007	0.40
80	1.399	0.006	0.34

Max. Error in Volts 0.020

Max. Error in Percent 1.13

SENSOR TRANSMITTER DATA SHEET

3.0 Power Supply Test

3.1 Test Equipment

DC Voltmeter	Model: Fluke 803B
	Serial No.: 1498
DC Milliammeter	Model: Weston 931
	Serial No.: 55921

3.2 Test Setup

The test setup shall be in accordance with paragraph 4.3.7 of this publication.

3.3 Test Data:

Battery Life Test

Initial Drain in MA @	Computed Service Life
V_1 ~~V_2~~ ~~V_3~~	V_1 ~~V_2~~ ~~V_3~~
V_1 = 7.98 @5.4 ma	92.5 hrs

24-Hour Error Test

Start		Stop		Error (volts)	Error (percent)
Date	______	Date	______		
Time	______	Time	______		
Rec Out	______	Rec Out	______	______	______

SENSOR TRANSMITTER DATA SHEET

4.0 Temperature Test

4.1 Test Equipment

Environmental Chamber	Model:
	Serial No.:
Digital Voltmeter	Model:
	Serial No.:

4.2 Test Setup

The test setup shall be in accordance with paragraph 4.3.8 of this publication.

Two transmitters will be checked simultaneously.

The transmitters will be calibrated at room temperature.

4.3 Test Data

Temp (°F)	Rec Input (volts)	Rec Output (volts)
40	2.500	2.477
100	2.500	2.518
140	2.500	2.528

Error in Volts 0.028

Error in Percent of full scale 0.56

SENSOR TRANSMITTER DATA SHEET

5.0 Transmission Range

5.1 Test Equipment

Field Intensity Meter	Model:
	Serial No.:
Tuning Unit	Model:
	Serial No.:
Antenna	Model:
	Serial No.:

5.2 Test Setup

The test setup shall be in accordance with paragraph 4.3.2 of this publication.

The loop antenna used in this test is to be oriented for maximum signal level.

5.3 Test Data

Range	Signal Level (db >luv/meter)	Assumed Noise Level (8 db)	S/N Ratio	Error* (percent)
____	________	________	____	_____

*Error is obtained from paragraph 4.3.2 in the test procedure. Maximum allowable error is 2 percent or +16 db S/N ratio.

SENSOR TRANSMITTER DATA SHEET

6.0 Interpretation of Error Measurements

As indicated in paragraph 4.4, the total system error is composed of the systematic and random components. The random component of the error is to be limited to 2 percent. The systematic error is to be limited to 4.5 percent. The total system error shall not exceed 5 percent and is composed of the vector sum of the random and systematic error. The systematic error is the RMS value of the error measured in paragraphs 1.0 through 4.0.

Random Error (E_R) = ______

Systematic Error (E_s) = 1.35%

System Error ($E = \sqrt{E_R^2 + E_s^2}$ = ________

SENSOR TRANSMITTER DATA SHEET

Transmitter VCO period versus Modulation Voltage

Volts	Period (usec)	ΔT (usec)
0.0	378.8	
1.0	398.5	19.7
2.0	418.4	19.9
3.0	438.4	20.0
4.0	458.2	19.8
5.0	478.2	20.0

SECTION 5

INTEGRAL SENSOR TRANSMITTERS
OPERATING AND MAINTENANCE INSTRUCTIONS

5.1 GENERAL

The transmitters are FM/FM modulated and are designed to accept a 0- to 5-volt modulation input. The input terminals are isolated from case ground so that either positive or negative voltages may be used for modulation provided the polarity markings are observed.

The accuracy of this system depends on three factors:

a. The dynamic response of the low-frequency oscillator in the transmitters which are designed to have an output frequency whose period varies from about 400 microseconds to 500 microseconds when the input is varied from 0 to 5 volts.
b. The period of the monostable multivibrator in the receiver which is compared to the low-frequency oscillator of the transmitter for a 0-volt input.
c. The setting of the digital-to-analog converter in the data recovery unit.

Calibration of the system consists of the adjustments to insure that these conditions have been met. A calibration jack is provided for calibration of the transmitter. Insertion of the calibrate plug automatically disconnects the modulation input. Also provided is a calibration source to give -1 volt and -4 volts for calibration.

5.2 TRANSMITTER CALIBRATION

5.2.1 TRANSMITTER ALIGNMENT

The following procedure should be performed prior to putting the transmitter in service and at each battery change:

a. Use Tektronix preamplifier 5354L on ac scale with X10 probe on antenna base.
b. Check for maximum oscillator output without spurious oscillations. If necessary, adjust buffer and antenna coils. Turn transmitter off and on. If oscillator fails to start, adjust oscillator coil.

c. Remove scope probe and use receiver for peak adjustments.
d. Connect Hewlett Packard 400D ac voltmeter or equivalent to IF output on receiver (BNC connector).
e. Connect scope probe at discriminator output of receiver (dual banana connector).
f. Adjust transmitter buffer coil for symmetrical signal at discriminator. Should approach a triangular wave. If necessary, adjust transmitter oscillator coil.
g. Adjust antenna coil for maximum deflection on voltmeter.

5.2.2 LOW-FREQUENCY OSCILLATOR ADJUSTMENTS

Prior to these tests, the calibration box, furnished with the transmitter, should be adjusted to give -1 volt and -4 volts using a laboratory voltmeter. Then perform the following adjustments:

a. Insert calibration plug.
b. Connect digital counter to transmitter test point and set counter to read period in microseconds to a tenth of a microsecond.
c. Switch calibration box from -1 volt to -4 volts and adjust transmitter calibration pot until counter shows 60-microsecond differential in period. Three or four adjustments are usually required. Shortest period must be greater than 380 microseconds.

5.3 RECEIVER STATION

The receivers described here are designed to be used in conjunction with the five percent transmitters and consist of the antenna, distribution amplifier, RF receiver and detector, and the data recovery unit.

5.3.1 ANTENNA

The antenna is a 27-Mc whip.

5.3.2 DISTRIBUTION AMPLIFIER (See Figure 5-1)

The distribution amplifier has the following characteristics:

a. Input - a single RF input (BNC connector).
b. Output - consists of 6 RF outputs (miniature coaxial connectors).
c. Power - operates from a -12 vdc supply.

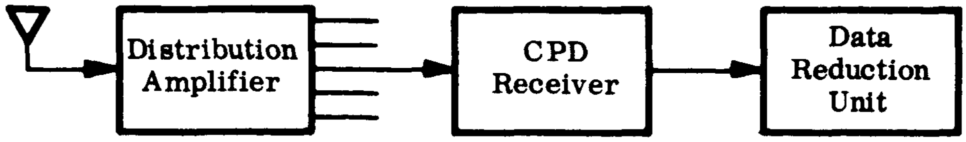


Figure 5-1. Connection Diagram

5.3.3 RECEIVER-DETECTOR

This is a modified commercial receiver. Each receiver serves two channels selected by a front panel switch. Power required is 12 vdc.

5.3.4 DATA RECOVERY UNIT

Each unit recovers data from a single channel. Both digital and analog is brought out, including a meter presentation of the analog output.

5.3.4.1 Analog Output

The data recovery unit should have the following characteristics:

a. The meter output is connected internally and will read directly.
b. The load impedance at the analog out terminals should be equal or greater than 1 meg.

5.3.4.2 Digital Output

The digital data, plus a transfer pulse, is available through a connector at the back of the unit.

Pin No.	Function
1	Transfer Pulse
3 5 7 9 11 13	6-Bit Digital Out Standard Logic (All "1"s full scale)
2 4 6 8 10 12	Complementary Logic
14	Ground

Notes:

1. Transfer pulse +3.5 ± 0.5 volts of 80-microsecond duration.
2. Information set into registers coincident with leading edge of pulse.
3. Binary "1" = +3.5 ± 0.5 volts.
4. Binary "0" = +0.05 ± 0.05 volts.

5.3.4.3 Power

The unit operates from ±12 vdc.

5.3.5 RECEIVER CALIBRATION

The following calibration procedure will be utilized:

a. Using panel meter or external voltmeter on the analog output, and with one volt in the transmitter, adjust "Calibrate Adjust" pot, on the top of the data recovery unit until the analog output reads one volt.
b. Set the transmitter input at 4 volts and, with the "Analog Adjust" pot on the data recovery unit face, set the output for 4 volts.
c. Repeat steps a. and b. as required. Calibration is now complete.
d. The receiver calibration should be repeated prior to each use of the system or at 24-hour intervals during operation. If an adjustment of more than one meter division is required, then the transmitter low-frequency oscillator adjustment should be checked.

5.4 TRANSMITTER INSTALLATION

The following installation procedure will be utilized:

a. Mount the transmitter in a convenient location near the measurement point using the tapped mounting holes in the transmitter case.
b. The transmitting antenna should be as far as possible from any metal structure to avoid detuneing the antenna. In all cases, paragraph 5.2.1, step d. should be repeated after installation.
c. The sensor leads should then be connected to the sensor input binding post, observing the polarity indications.

5.5 RECEIVING STATION INSTALLATION

The Receiving Station consists of three receivers, a distribution amplifier, two data recovery units, and two power supplies housed in a utility cabinet. The following installation procedure will be utilized:

a. Attach whip antenna to cabinet.

b. Plug in ±12 volt power supplies.

c. Switch on power supplies, receiver, and data recovery unit.

5.6 TRANSMITTER MAINTENANCE

The four batteries in the transmitter battery pack should be replaced at the end of each 100 hours of operation. Care should be exercised to insure the batteries are replaced with the polarities marked on the battery pack. The (+) sign means the positive end of the battery should be up. The same is true for the (-) sign. For normal operation above 40°F, Mallory type TR - 162 R batteries or equivalent should be used. For operation near 40°F or below, Mallory type 303474 (2-RM 640 WA cells) batteries are recommended.

The only other maintenance required is the periodic calibration and the transmitter alignment at each battery change.

5.7 DATA RECOVERY UNIT CALIBRATION CURVE

The attached calibration curve (Figure 5-2) is to be used to supply correction factors to be used when making measurements involving ac signals above about 30 cps. The Data Recovery Unit samples the period of the VCO frequency to extract the data signal. This sampling is, of course, accomplished by a finite width pulse. The sampling is developed for inpulse samples and the original signal can be recovered without error only if the samples are inpulses. The magnitude of the error is calculable from a knowledge of the sampling pulse width and is the basis for the calibration curve. The magnitude of the ac signal read from the Data Recovery Unit should be multiplied by the appropriate correction factor from the curve to obtain the true transmitted signal amplitude.

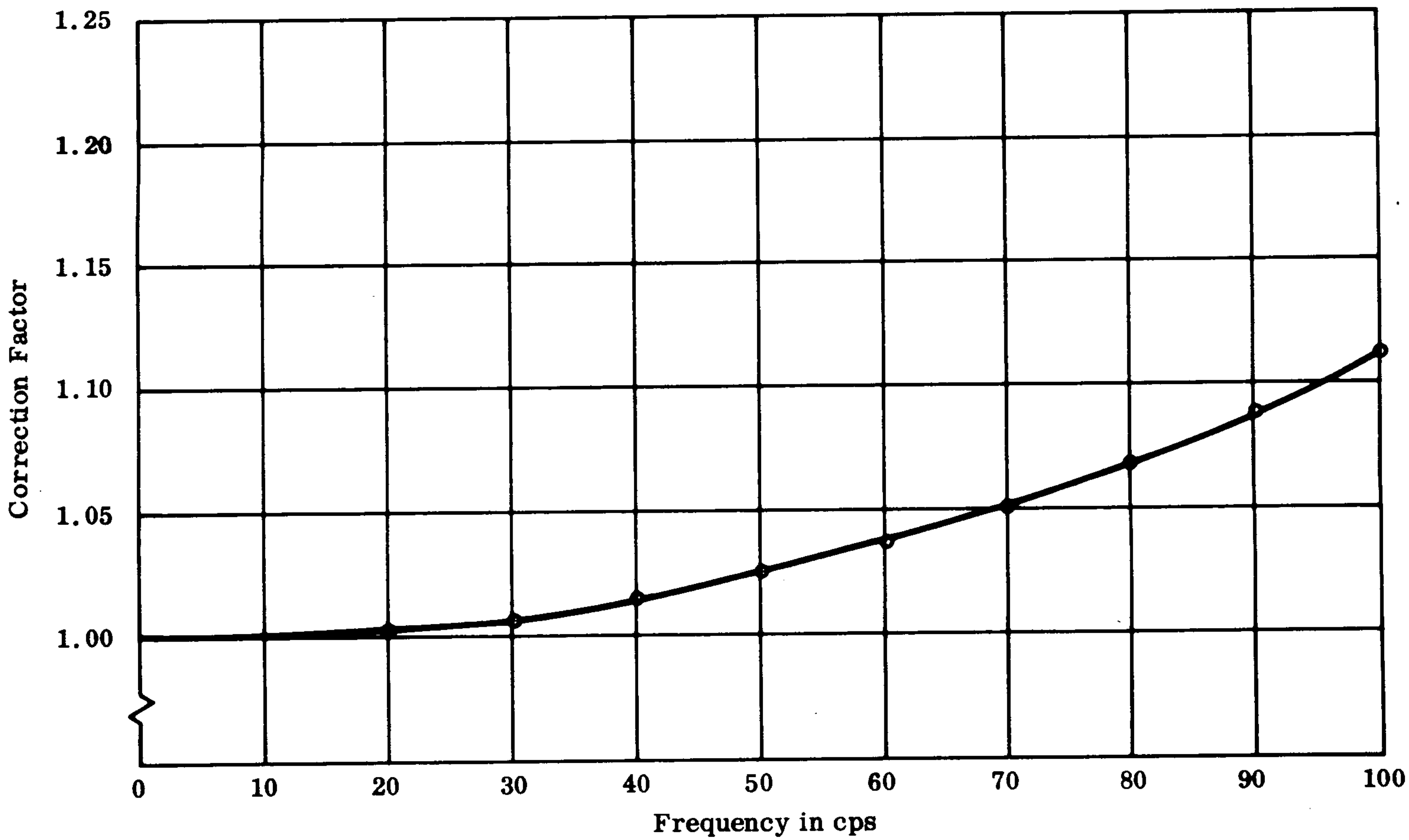


Figure 5-2. Data Recovery Unit Calibration Curve

SECTION 6

CONCLUSIONS

6.1 PHASE A, PART 1

The results of Phase A indicate that the use of a sensor transmitter system on the module carts of the ATCOMED facility is entirely feasible. The equipment evaluation of presently available sensor transmitters shows that the transmitter will meet the specifications for the five-channel system, with the exception of the 100-hour battery life. Planned improvements in the transmitter circuitry will improve the transmitter efficiency and extend the battery life beyond the present 80 hours of continuous operation.

6.2 PHASE A, PART 2

The use of an integral sensor system on board a space vehicle during factory checkout can greatly facilitate the gathering of test data from test points other than those of the flight instrumentation system. The use of such a system allows data to be taken with a minimum of setup time and with the least possible hazard to other areas of the vehicle.

The results of this study indicate that the requirements for an integral sensor system to operate on board a vehicle can be met. Those features which are required for a system of this type that are not yet available, such as remote turn-on/turn-off, have been shown to be feasible and could be incorporated into the integral sensor system. The increased accuracy required for this application will be available using improved system components presently under development on the General Electric Contractors Independent Research and Development Program. One area in which some question exists is the propagation of RF energy inside the enclosed area of the vehicle. This area is discussed in detail in paragraph 4.3.1 of the Phase A report. Based on experimental results obtained in this program, there should be little difficulty in overcoming the increased attenuation of such an environment. To definitely prove this contention, however, will require a test under actual operating conditions.

To realize maximum value from the integral sensor system it should be considered as a special test system as opposed to a general-purpose telemetry system. In this way the sensor and transmitter can be matched to eliminate signal conditioning and, in some cases, the need for excitation voltage for the sensor. This technique will make the placement of sensors even more flexible.

6.3 PHASE B

The test data obtained from the sensor transmitters indicate that they will be well within the 5 percent over-all accuracy required by the Phase A specification. Three, and possibly four, of the five transmitters should be within the 3-percent design goal depending on the magnitude of the random error component to be determined by the transmission range test. This error should be 2 percent or less and from other tests in this frequency range should be nearer 1 percent.

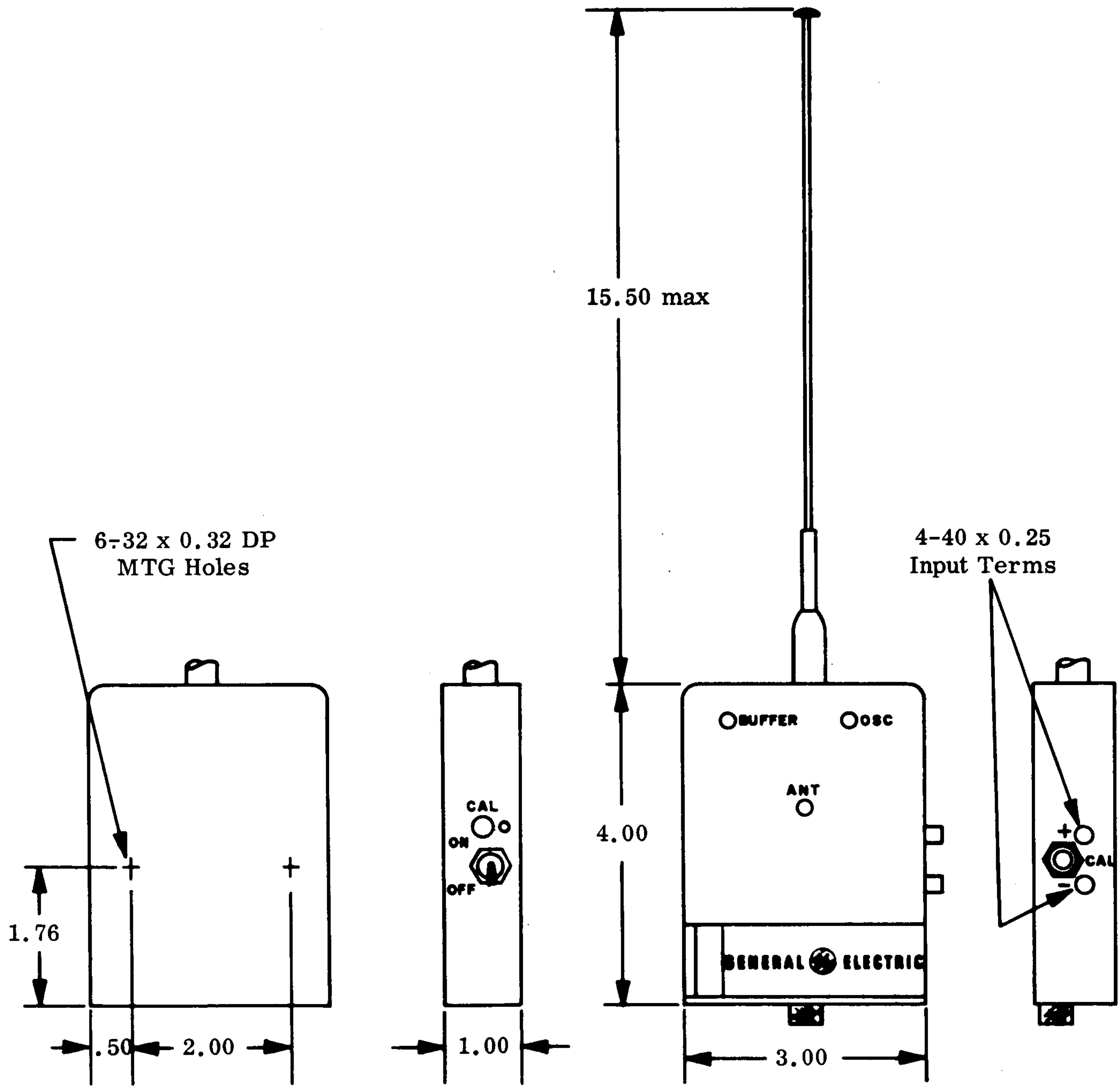
The calculated battery life indicates that most of the critical transmitter batteries will be exhausted in something under the 100 hours specified. The shortest time is 88 hours and the longest time is 111 hours. Previous life testing, however, has shown the rating on the batteries is somewhat conservative so that actual battery life should be very close to 100 hours.

Using the modified commercial receivers supplied on load with the transmitters, some problems with cross-channel interference was noted. It was found if the jamming signal exceeded the desired signal by approximately 20 db significant interference was observed. In using these receivers care should be exercised in transmitter placement to insure that adjacent channels are not operated at too large a difference in signal levels.

In total, the five transmitters delivered in Phase B of the contract meet the requirements and specifications established in Phase A of the program. These devices should be suitable for establishing the feasibility of the integral sensor concept in the ATCOMED facility environment.

APPENDIX

(SPECIFICATION CONTROL DRAWING)



Dimensions are for Reference only

TRANSMITTER OUTLINE